Beamline Steering Displays

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This document is intended as a reference guide for beamline trajectory / steering displays

IDxbpm.adl
BMxbpm.adl

These displays contain the data used by the APS storage ring orbit correction algorithm to stabilize the DC orbit. They are accessed by two top level medm screens, availablestarting from the top level screen XFD-Display.adl . The two top-level screens are in files IDSectors.adl and BMSectors.adl ,

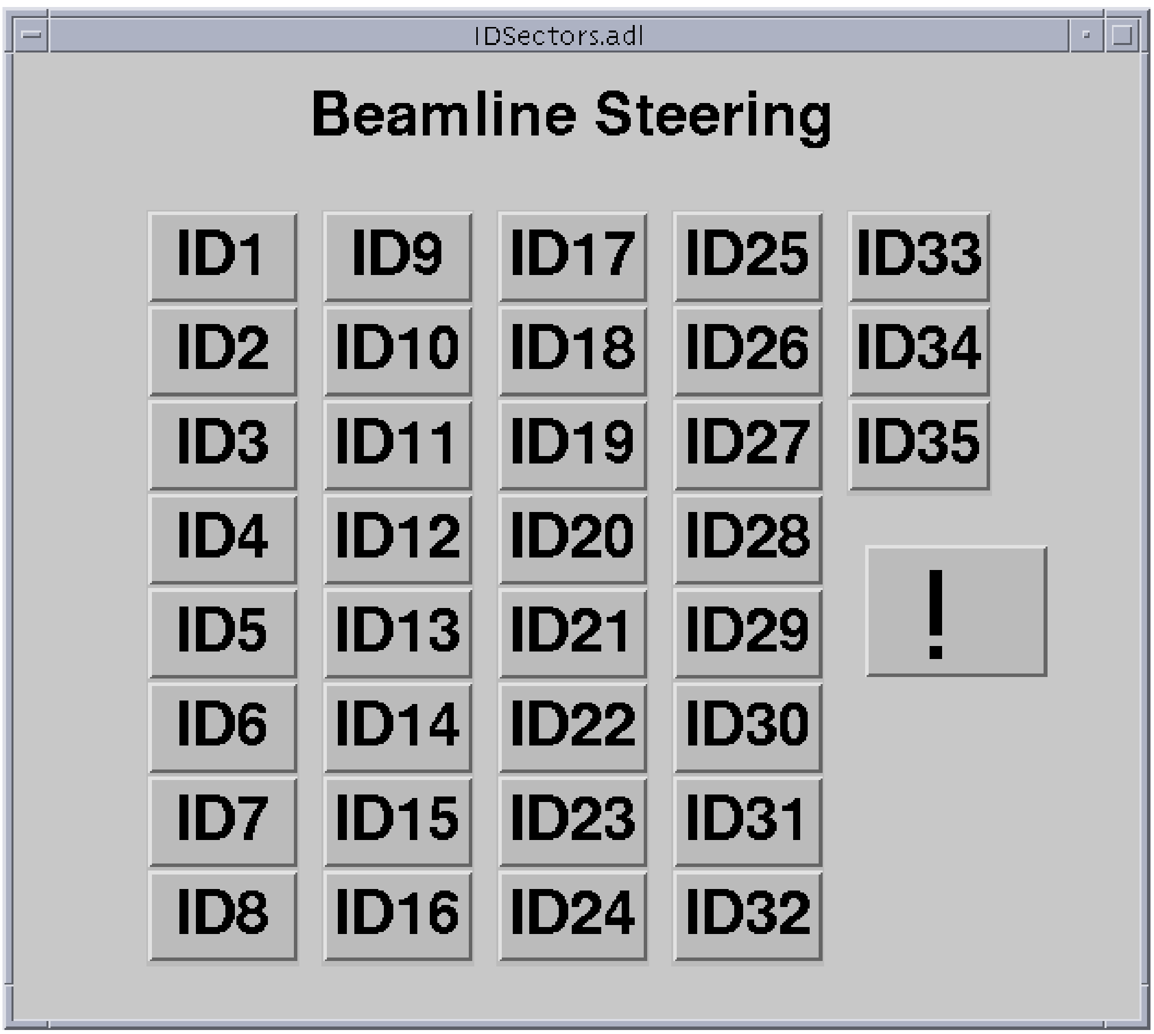

Figure 1 Top level insertion device screen (primarily for floor coordinators)

The top level display BMSectors.adl is entirely analagous to that shown in figure 1 for the insertion devices. Clicking on one of the above buttons brings up a related display specific to a particular beamline, for example ID 14, shown in figure 2 below. Source code for the displays of the type shown in figures 2 and 3 are available from the web page at

http://www.aps.anl.gov/asd/diagnostics/xbpmDisplays/index.html

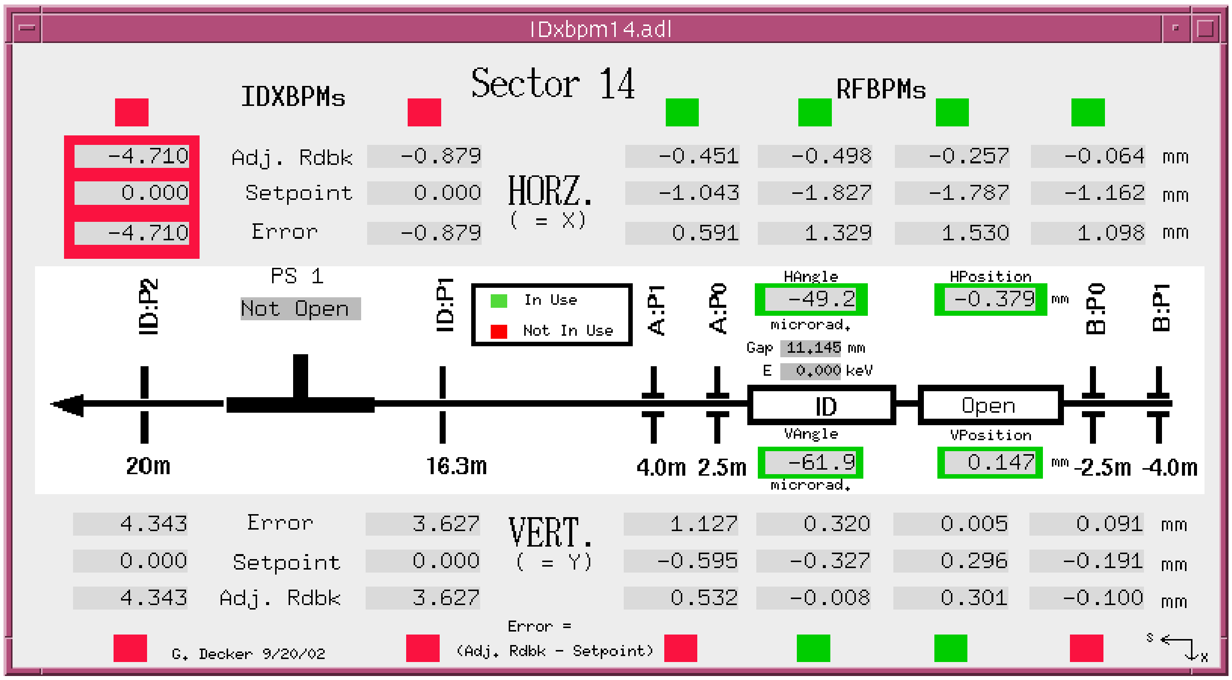

Figure 2. Example display for insertion device beamline ID14

The photon / particle beam trajectory is displayed travelling from right to left, with six associated beam position monitors displayed. According to accelerator physics convention, positive x = horizontal position is outboard, e.g. down on this screen. I turned it upside down just for the users. The labels A:P1, A:P0, B:P0 and B:P1 refer to radio frequency particle beam position monitors (bpm's). The so-called P0 bpm's are narrow-band rf bpm's attached to 4-mm diameter capacitive button pickup electrodes mounted on the small aperture insertion device vacuum chamber. They tend to be our most reliable position monitors, and are almost always used unless malfunctioning. On the insertion device screens, the source parameters HAngle, HPosition, VAngle, and VPosition are derived from the P0 readbacks as follows:

HAngle = 1000* [(A:P0 Horz. Adj. Rdbk) - (B:P0 Horz. Adj. Rdbk)] / (5 meters)
(microradians)
HPosition = [(A:P0 Horz. Adj. Rdbk) + (B:P0 Horz. Adj. Rdbk)] / 2
(millimeters)

The (5 meters) in the formula for HAngle is the distance between the P0 bpm's that straddle the ID source point. (The actual number used is a process variable e.g. S1:ID:MetersBetweenBpmsP. Its value is exactly 4.944 meters for all except ID11 which uses P1 bpm's separated by 7.948

meters, and ID34 which has a half-length chamber, with 2.454 meters separation). The parameters VAngle and VPosition are calculated in a completely analagous fashion from P0 readbacks..

Notice the field of red surrounding the data corresponding to the ID:P2 bpm in figure 2. This monitor malfunctioned, and the fact that it is a known bad bpm is indicated by having the background light up red. In addition, a red square adjacent to the red field indicates that the monitor is not being used by the orbit correction algorithm Fortunately, data from the broken unit is being ignored. Notice the red square adjacent to the A:P1 and B:P1 vertical data. These monitors are functioning, but not being used by the algorithm, for the simple reason that the P0 data is believed to be more reliable than the P1 data in the vertical plane (rogue microwave disease). When P0 data is unreliable, the orbit correction algorithm uses P1 data. If the problem with the P0's is irreparable (e.g. at beamline 11 ID) we have modified the Angle and Position pv's to use P1 data.

For each bpm, six numbers are displayed, three for each plane (horz, vert). The three numbers are labeled "Adj. Rdbk.", "Setpoint", and "Error". The adjusted readback is the position reading as measured by the bpm data acquisition system (after correcting for things like intensity dependence in the case of rf bpm's and, very soon, gap dependence in the case of insertion device x-ray bpm's). For the rf bpm's, this adjusted readback is our best estimate of the displacement of the particle beam relative to a known and reproducible datum, namely the magnetic center of adjacent focusing (quadrupole) magnets. The Setpoint is a static number reflecting the desired readback, and the Error is the difference (adjusted readback - setpoint) . The setpoint usually only changes when local steering is requested, although a significant amount of database gymnastics is required to reproduce the orbit following a maintenance period, for example. It turns out to be convenient for the orbit correction algorithm to make something zero, thus a display of these differences is a good way to show how well the algorithm is doing. All numbers associated with bpm's in this display are in units of millimeters, while angles are measured in microradians.

For completeness, the analagous readbacks, setpoints, and errors are shown for the two insertion device x-ray beam position monitors located in the beamline front end. In this case the datum relative to which the readbacks are measured is not as well defined, since the x-bpm's are mounted on horz / vert mechanical translation stages. Generally it is best to operate the x-bpms such that the beam is approximately centered in the device, where their response is most linear. The readbacks will ultimately be corrected for gap-dependent effects, giving a reasonably reliable diagnostic. For fixed gap operation, the insertion device x-bpm's are our most sensitive diagnostic, however the systematic gap-dependent effects have limited their use in an absolute sense. I successfully tested the first feedforward algorithm to deal with this on June 11, so it shouldn't be long before the id xbpm's are actively in use. The display indicates zero setpoint for the idxbpm's simply because these units are not yet fully commissioned.

Also, the upstream and downstream accelerator components must be displaced by up to 6 mm (the decker displacement) to have any hope of performing the corrections necessary to deal with gap changes. As of run 2-03 (Oct. - Dec. 2002), decker displacements are complete for sectors 2, 3, 4, 5, 6, 7, 15,16,18,19,20,22, 32,33, and 34. Sectors 9,10, and 21 will be done in January. For any given ID beamline, both the upstream and downstream sectors must be displaced to receive the full benefit of the girder displacements, viz, reduction of stray radiation background signals on insertion device x-ray beam position monitors.   The status and schedule for accelerator displacements are available from

http://www.aps.anl.gov/asd/survey/images/sectormove.gif
and
http://www.aps.anl.gov/asd/diagnostics/xbpmDisplays/distortSched.txt

In addition to bpm data, the insertion device gap and photon energy are displayed in figure 2, to assist in interpreting the x-bpm data. The ID xbpm's generally cannot be expected to work for gaps much larger than about 30 mm, simply because the signal becomes too small relative to stray radiation background signals.

Shown in figure 3 is a display representing beamline 14BM

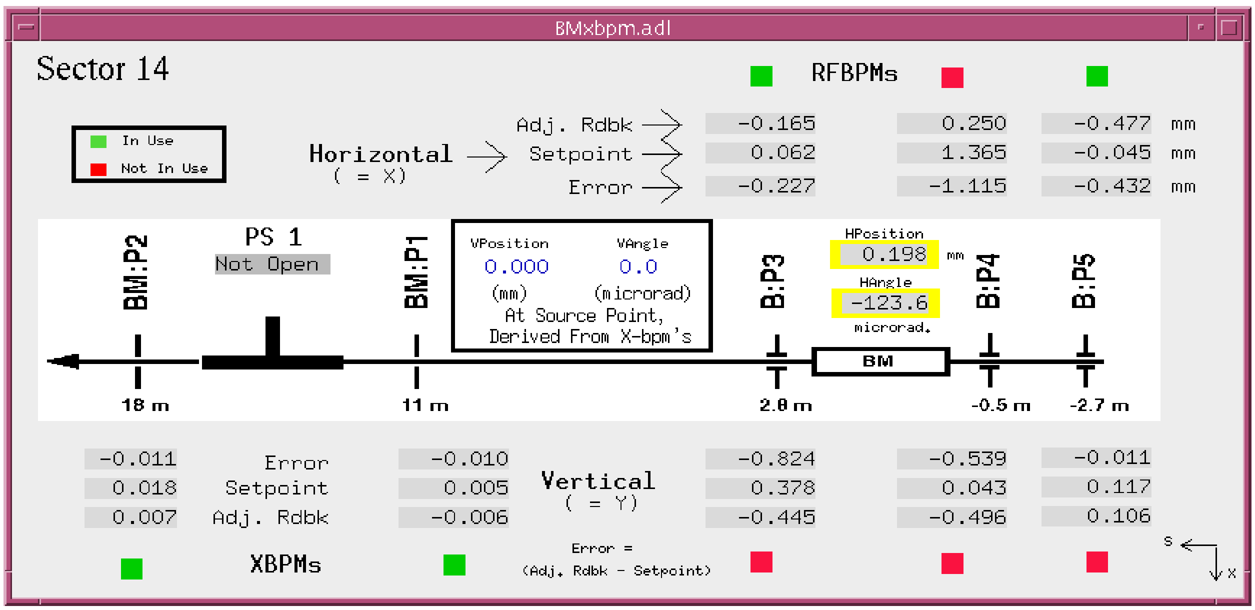

Figure 3. Example display for bending magnet beamline BM14

The major difference between this display and the insertion device displays (besides there being no insertion device) is that the x-bpm's are much more reliable than the rf bpm's. Also the x-ray bpm's only work in the vertical plane. Because of this, the derived angle and position process variables are derived as follows (straight from frank's source code):

VAngle = 1000* [(BM:P2 Adj. Rdbk) - (BM:P1 Adj. Rdbk)] / (18.0 meters - 10.9 meters)
(microradians) (note BM:P1 is actually 10.9 meters from the source - I rounded off above)
VPosition = (BM:P1 Adj. Rdbk) - (VAngle/1000)*10.9 meters <- note extrapolation
(millimeters)

HAngle = 1000* [(B:P3 Horz. Adj. Rdbk) - (B:P4 Horz. Adj. Rdbk)] / (3.3545 meters)
(microradians)
HPosition = [(B:P3 Horz. Adj. Rdbk) + 7*(B:P4 Horz. Adj. Rdbk)] / 8
(millimeters) (note source point is approx. one eighth of the way from BP4 to BP3)

Appendix A - Process Variables

Derived ID source parameters

S*:ID:SrcPt:xAngleM	Horizontal angle at center of id straight section.
S*:ID:SrcPt:xPositionM	Horizontal position, = average of BP0x and AP0x
S*:ID:SrcPt:yAngleM	Vertical angle at center of id straight section.
S*:ID:SrcPt:yPositionM	Vertical position.

Where the * is a wildcard denoting the sector number of interest (no prepending zero here, i.e. S1:ID:SrcPt:xAngleM, _not_ S01:ID:SrcPt:xAngleM. These values are derived from the P0 narrowband rfbpm adjusted readbacks.

Derived BM source parameters

S*:BM:SrcPt:xAngleM	Horizontal angle at BM source point (from rfbpms)
S*:BM:SrcPt:xPositionM	Horizontal position at BM source point (from rfbpms)
S*BM:VANGLE:CC	Vertical angle at BM source point (from xbpm's)
S*BM:VPOSITION:CC	Vertical position at BM source point (from xbpm's)

Monopulse rf bpm's

All monopulse beam position monitors' process variables names are of the form

S*[AB]:P[12345]*[xy]*

Where the * is a wildcard, and the characters between square braces [] are enumerated lists. For example, the relevant readbacks for bpm S19A:P1 are

Horizontal:

S19A:P1:mswAve:x	Raw horizontal readback
S19A:P1:ms:x:OffsetAO	Difference between electronic and magnetic center
S19A:P1:mswAve:x:AdjustedCC	Horizontal readback relative to quad. magnetic center
S19A:P1:ms:x:SetpointAO	Desired horizontal position, relative to magnetic center
S19A:P1:mswAve:x:ErrorCC	Adjusted - Setpoint: displacement relative to desired

Vertical:

S19A:P1:mswAve:y	Raw vertical readback
S19A:P1:ms:y:OffsetAO	etc.....
S19A:P1:mswAve:y:AdjustedCC	
S19A:P1:ms:y:SetpointAO	
S19A:P1:mswAve:y:ErrorCC	

For the process variables with the symbols mswAve embedded within them, analogous process variables with higher analog bandwidth exist with the replacement

mswAve -> ms   or mswAve -> msAve

The pv's e.g. S19A:P1:ms:y have analog bandwidth of about 30 Hz and are heavily aliased at epics data rates. PV's of the type S19A:P1:msAve:y have 1 Hz analog bandwidth. The mswAve process variables have about a 20 second time constant and are the only way to see things happening at the sub-micron scale. Incidentally, the hardware boxcar averager was named the "memory scanner" by an engineer long ago, explaining the ms portion of the pv name. The epics ioc performs further averaging to arrive at the msAve and mswAve (memory scanner average and memory scanner weighted average) values.

It's probably worthwhile to look at the nomenclature document that I wrote more than ten years ago, available on the web at

http://www.aps.anl.gov/techpub/lsnotes/ls191/ls191.html

Narrow-band rf bpm's

Even though the narrow band rf bpm's and x-ray bpm's do not have hardware averagers, the nomenclature ms, msAve, and mswAve have been retained as reminders of what analog bandwidth is available. Thus all narrow band rf bpm's are of the form S*[AB]:P0*[xy]* :

S19A:P0:mswAve:x	Raw horizontal readback
S19A:P0:ms:x:OffsetAO	Difference between electronic and magnetic center
S19A:P0:mswAve:x:AdjustedCC	Horizontal readback relative to quad. magnetic center
S19A:P0:ms:x:SetpointAO	Desired horizontal position, relative to magnetic center
S19A:P0:mswAve:x:ErrorCC	Adjusted - Setpoint: displacement relative to desired

and similarly for the vertical plane (y).

The averaging for the P0 (narrow band) rf bpm's is performed by an analog low pass filter to arrive at the 30 Hz ms process variables. For the msAve and mswAve's, a proper digital filter using a dedicated digital signal processor is used to generate the slower msAve and mswAve pv's Since the P0 bpm's are not near quadrupole magnets, their "magnetic" center is defined relative to a straight line connecting the centers of the quadrupole magnets located immediately upstream and downstream of the insertion device source point.

Bending Magnet X-bpm's

Bending magnet x-ray beam position monitor process variables take the form S*BM:P[12]*y* :

S19BM:P1:mswAve:y	Raw vertical readback
S19BM:P1:ms:y:OffsetAO	Difference between electronic and "mechanical" center
S19BM:P1:mswAve:y:AdjustedCC	Vertical readback relative to mechanical center

S19BM:P1:ms:y:SetpointAO	Desired vertical position, relative to mechanical center
S19BM:P1:mswAve:y:ErrorCC	Adjusted - Setpoint: displacement relative to desired

The P1 BM xbpm is 11 meters from the source, and the P2 BM xbpm is 18 meters
There are no analogous horizontal process variables for bending magnet x-bpm's.
The OffsetAO process variables are typically set to zero and are supported primarily only to provide standardized notation relative to the other bpm's.

Insertion Device X-bpm's

For insertion device x-ray bpm process variables, simply replace BM with ID in the above, and add horizontal readbacks: S*ID:P[12]*[xy]* :

S19ID:P1:mswAve:y	Raw vertical readback
S19ID:P1:ms:y:OffsetAO	Difference between electronic and "mechanical" center
S19ID:P1:mswAve:y:AdjustedCC	Vertical readback relative to mechanical center
S19ID:P1:ms:y:SetpointAO	Desired vertical position, relative to mechanical center
S19ID:P1:mswAve:y:ErrorCC	Adjusted - Setpoint: displacement relative to desired

and similarly for the horizontal (x)

In this case, the OffsetAO will be used in a feedforward algorithm to compensate for insertion device gap-dependent systematic effects. A mechanical translation stage is used to place the bpm's electronic center "near" the user's desired location. Thus the AdjustedCC process variable represents our best approximation to a "gap-independent" position readback.

In addition to the position-related process variables, two flavors of status bits are indicated on the medm screens described herein, which are indicated in one case by a red or green "light" and in the other by red or "nothing".

PV's of the type S*[xy]:BadBO indicate that a particular bpm is bad. If so, the background surrouding the associated position readback values will turn red, flagging the fact that the data is beyond suspect and not to be believed. If this process variable indicates "not bad", then no indication is given, i.e. "nothing".

The pv's S*[xy]:InUseBO indicate whether or not a particular process variable is included in the DC orbit control algorithm. If the light above the horizontal readback values (or below the vertical) is green, then that channel is being used to correct the orbit. Red means that the process variable is not in use. We tend to use the most believable readbacks for orbit control and omit any that have the slightest suspicion of being fishy. In particular, in the vertical plane the monopulse rf bpm's all are affected at some level by a disease known as the "rogue microwave" mode, which is simply a microwave mode with vertical electric field and a frequency falling inside the bpms' passband. The monopulse bpm's are still useful for relatively short time periods, and some are better than others, but our most reliable readings are the narrow-band rf (P0) and BM x-bpm's. Horizontally, as many rf bpm's as possible are typically used.